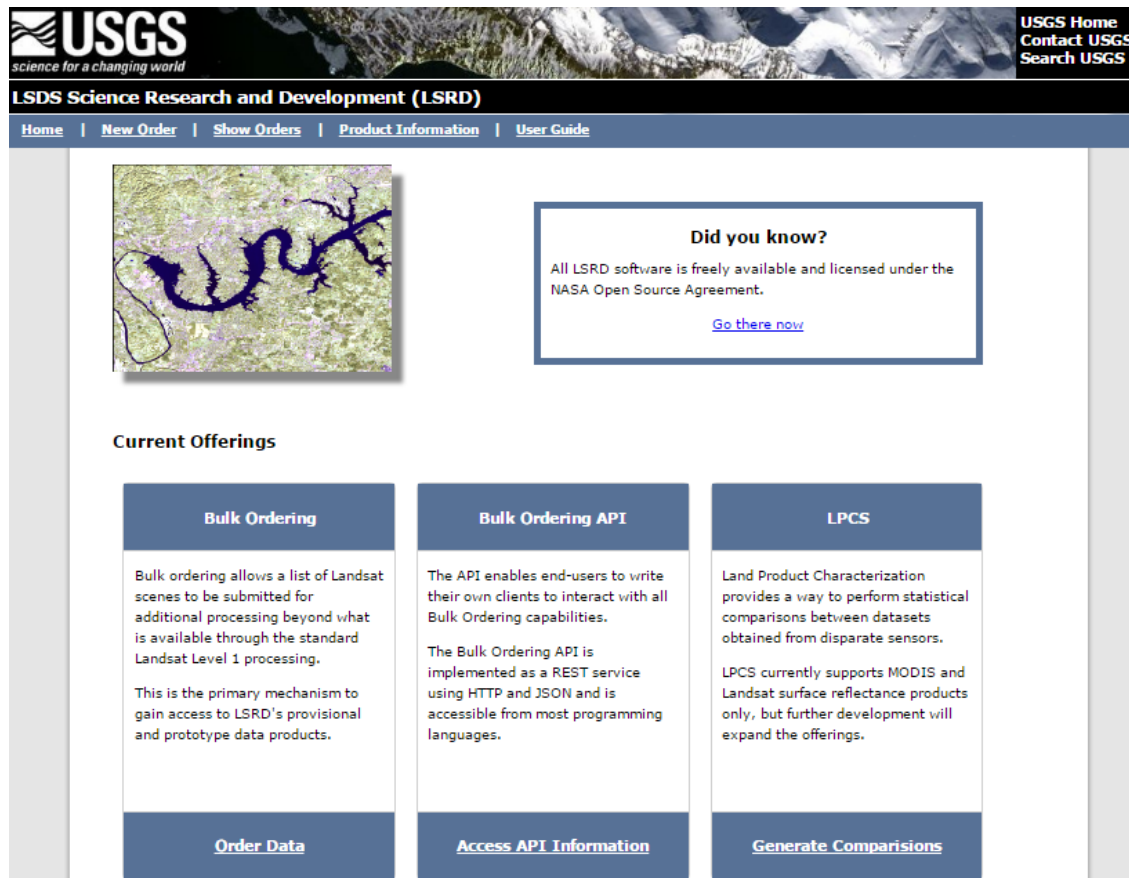Department of the Interior
U.S. Geological Survey

USER GUIDE

EARTH RESOURCES OBSERVATION AND SCIENCE (EROS) CENTER SCIENCE PROCESSING ARCHITECTURE (ESPA) ON DEMAND INTERFACE

Version 3.5

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Document History

Document Version	Publication Date	Change Description
1.0	11/11/2013	Initial Draft
1.1	12/01/2013	Revised after Peer Review
1.2	01/06/2013	Updated with DownThemAll network preference instruction
1.3	06/04/2014	Corrected link to SI Product Guide
1.4	06/26/2014	Modified system login details
2.0	07/29/2014	Added new output format and projection option descriptions
2.1	08/04/2014	Added file format characteristics and appendices.
2.2	08/27/2014	Added MODIS MOD/MYD09 & MOD/MYD13 input options, output files; GeoTIFF output files added; 'fmask' changed to 'cfmask' in file output.
2.3	10/10/2014	Split processing options into more subsections, Land Product Characterization System (LPCS) integration, statistics generation, ability to download only metadata, users must "Define Projection" before modifying image extent.
2.4	10/22/2014	Expanded descriptions of reprojection parameters, updated on demand order page figure to include statistics generation.
2.5	12/23/2014	Updated "Customization Options" section to show that QA bands are always resampled with Nearest Neighbor. Addition of Landsat 8 products. Updated figures and text to reflect ESPA website updates. Added LPCS processing addition to ESPA.
2.6	03/25/2015	Added ESPA Bulk Download client information to "Download" section.
2.7	9/22/2015	Corrected URLS in document
2.8	10/19/2015	Changed number of days in Section 2.3; adjusted server limits in download plugin documentation and graphic
2.9	12/01/2015	Minor formatting and typo corrections.
3.0	12/16/2015	Added caveat for maximum pixel count per grid. Updated tables to indicate cloud mask (CFmask) ordering option for Landsat products.
3.1	03/01/2016	Added caveat for Intercomparison & Statistics generation – currently not supported for Landsat Level 1 products.
3.2	05/10/2016	Updated link for ESPA bulk download client.
3.3	07/01/2016	Added description of order status messages. Updated links to L8 Surface Reflectance Code (LaSRC) Product Guide.
3.4	10/07/2016	Added API information, NetCDF output & corresponding graphics.

3.5	12/07/2016	Updated links to Landsat Missions Website

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Section 1   **Introduction**

Landsat data have been produced, archived, and distributed by the U.S. Geological Survey (USGS) since 1972. Scientists and users rely on these data for historical study of land surface change, but shoulder the burden of post-production processing to create applications-ready data sets. In compliance with guidelines established through the Global Climate Observing System, USGS has embarked on production of higher-level Landsat data products to support land surface change study. Terrestrial variables such as surface reflectance and land surface temperature will be offered as Climate Data Records (CDR). Derivations of spectral indices from surface reflectance are also produced, to further ease user application in land remote sensing science. Higher level products, such as leaf area index, burned area extent, snow covered area, and surface water extent representing Essential Climate Variables (ECV) will be available soon.

These products are provided in order to build a framework for producing long-term Landsat data sets suited for monitoring, characterizing and understanding land surface change over time. The framework's implementation includes basic processing services for both Level 1 data and higher level products to provide applications-ready datasets to the user community. These services include:

- Reprojection*
- Spatial subsetting
- Pixel resizing*
- Multiple output formats

*These options do not apply to the Panchromatic Band (Band 8 Landsat 7 ETM+ and Band 8 Landsat 8 OLI.)

Products and services are provided by the USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA) On Demand Interface (https://espa.cr.usgs.gov/). It is composed of the following key elements:

- Bulk Ordering
- Bulk Ordering Application Programming Interface (API)*
- Land Product Characterization System (LPCS)**

This guide focuses on the Bulk Ordering component, which is the primary mechanism for access to USGS provisional and prototype data products.

*The API feature is available for all registered users. The API enables end-users to write their own clients to interact with all Bulk Ordering capabilities. More information about the API can be found in **Section 3 Application Programming Interface (API)**.

**LPCS is a collaboration between the USGS and National Oceanic and Atmospheric Administration (NOAA), and provides a way to perform statistical comparisons between data sets acquired from multiple sensors. It supports Moderate Resolution Imaging

Spectroradiometer (MODIS) and Landsat surface reflectance and vegetation index products only, but further development will expand the offerings. See section **2.1.8 Intercomparison & Statistics** for details.

Section 2   **User Interface**

The bulk ordering interface is the primary mechanism used to request on demand processing and services for the Landsat and select MODIS archives. With the exception of some periods of unavailability, all Thematic Mapper (TM) data from Landsat 4 and 5, available Enhanced Thematic Mapper Plus (ETM+) data from Landsat 7, and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) can be submitted for higher level product delivery. Caveats and constraints are for Landsat imagery are described in the Landsat 4-7 Surface Reflectance (LEDAPS) Product Guide, and the Provisional Landsat 8 Surface Reflectance Code (LaSRC) Product Guide, which link from the bulk order page through the "Product Information" menu on the top left of the interface panel.
Select MODIS MOD09 (Terra), MYD09 (Aqua), MOD13 (Terra) and MYD13 (Aqua) Collection 5 datasets are available to order through the bulk ordering interface. Available MOD/MYD09 datasets are all surface reflectance products, including:

- MOD/MYD09A1
- MOD/MYD09GA
- MOD/MYD09GQ
- MOD/MYD09Q1

Available MOD/MYD13 consist of all Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) products, including:

- MOD/MYD13Q1
- MOD/MYD13A1
- MOD/MYD13A2
- MOD/MYD13A3

Unlike Landsat-based products, the number of processes are limited to the ESPA Source Products and Customization Options; Climate Data Records and Spectral Indices cannot be applied to MODIS products. Scenes can be ordered separately or concurrently with Landsat bulk orders. See **Table 2-1** for more details.

On Demand Order
To submit an order for high level data production, users interact with the "New Order" page on the bulk ordering interface: https://espa.cr.usgs.gov/. The page consists of three sections: announcements, scene list upload, and product options, as shown in **Figure 2-1**.

2.1.1 Login Credentials

A USGS Registered Username and password is required to access the bulk ordering interface. Users may use the same login credentials used to access EarthExplorer (https://earthexplorer.usgs.gov). To register and create USGS credentials, visit https://ers.cr.usgs.gov/register/.

2.1.2 Scene List

The first step in submitting an order for high level production is to create a scene list. This is a simple text file (*.txt) listing one Landsat or MODIS scene identifier (filename) on each line. The list can be easily generated by performing a spatial and temporal inventory search through EarthExplorer and exporting search results to a spreadsheet from which filenames can be extracted. Saving a scene list through the USGS Global Visualization Viewer (GloVis - http://glovis.usgs.gov/) is another option.

Users are advised to include no more than 5,000 scenes in a single order, although more scenes can be completed when system resources are available. Generally, smaller orders can be delivered faster. An example of a scene list is below:

espa_request.txt

LC81750832014323LGN00
MYD13Q1.A2002185.h19v05.005.2007176090149
MOD09GA.A2001024.h20v17.005.2006351175917
LE72101172013061ASN00
LT40230281982346XXX04
LT50230281984344XXX02

Add Input Products (Show Available Products)

Scene List
Browse... No file selected.

Select Product Contents

Source Products
☐ Input Products
☐ Input Product Metadata

Additional Processing (Landsat Only)

Climate Data Records
☐ Surface Reflectance

Other Landsat Level-2 Products
☐ Top of Atmosphere Reflectance
☐ Brightness Temperature
☐ CFMask
☐ Spectral Indices

Customize Outputs

Customization Options
Output Format ⦿ GeoTiff ◯ ENVI ◯ HDF-EOS2 ◯ NetCDF
☐ Reproject Products
☐ Modify Image Extents
☐ Pixel Resizing

Intercomparison & Statistics
☐ Plot Output Product Statistics

Add Order Description

Order Description (optional)

Submit

Figure 2-1 ESPA On Demand Order Page

2.1.3   Supported Processing Options By Product

Table 2-1 Available ESPA On Demand Processing Options

TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, MODIS Moderate Resolution Imaging Spectroradiometer

Product	Landsat TM, ETM+, OLI/TIRS	Select MODIS 09 & 13
Input Product	X	X
Input Product Metadata	X	
Climate Data Records	X	
Spectral Indices	X	
Customize Outputs	X*	X
Intercomparison & Statistics	X**	X

* Reprojection and pixel resizing options do not apply to the Panchromatic Band (Band 8 Landsat 7 ETM+ & Band 8 Landsat 8 OLI only.)
** Intercomparison & Statistics apply to all data products except the Landsat Level 1 data products.

2.1.4   Source Products

The ESPA on demand interface offers several products and some basic processing services in the "Source Products" section:

- The Original Input Products are the original Level 1T Landsat scenes, MOD/MYD09, MOD/MYD13 scenes and metadata downloaded directly from the USGS or Land Processes Distributed Active Archive Center (LP DAAC). L1T characteristics are described on https://landsat.usgs.gov/landsat-processing-details (Landsat 4-7) and on https://landsat.usgs.gov/landsat-8 (Landsat 8).
  MODIS characteristics are described on https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table.
- Original Input Metadata is included when source products are requested, but is selectable as a separate option to serve users who want that information to go along with one of the high level products without having to download an entire Landsat Level 1 package.
  - o   Original Input Metadata is not available for MODIS products.
- Customized Input Products use Original Input Products and applies any selections from the "Customization Options" section.
  - o   Customized Input Products must be checked for output format, projection, resizing,

2.1.5   Climate Data Records

"Climate Data Records" includes Landsat-derived products currently available as provisional USGS CDRs. Current offerings include:

- Top of Atmosphere (TOA) reflectance (multispectral bands data)
- Brightness Temperature (thermal band(s) data)

- CFmask*
- Surface Reflectance (multispectral bands data)

These products are described in detail in the Landsat 4-7 Surface Reflectance (LEDAPS) Product Guide and the Provisional Landsat 8 Surface Reflectance Code (LaSRC) Product Guide.

*CFmask is a quality band consisted of cloud, cloud shadow, snow/ice and water, derived from TOA reflectance data. It is included by default in the Surface Reflectance product, but can be ordered separately in the ESPA ODI.

2.1.6 Spectral Indices

The "Spectral Indices" section lists several band ratios that are derived from the Landsat surface reflectance product. Choices include:

- Normalized Difference Vegetation Index (NDVI)
- Enhanced Vegetation Index (EVI)
- Soil Adjusted Vegetation Index (SAVI)
- Modified Soil Adjusted Vegetation Index (MSAVI)
- Normalized Difference Moisture Index (NDMI)
- Normalized Burn Ratio (NBR)
- Normalized Burn Ratio 2 (NBR2)

The characteristics of each are described in the Spectral Indices Product Guide: https://landsat.usgs.gov/sites/default/files/documents/si_product_guide.pdf.

Development is ongoing for several additional data products, such as Burned Area, Surface Water Extent, Snow Covered Area, and Land Surface Temperature. They will be added to the product selections when they reach provisional status.

2.1.7 Customization Options

Clicking any of the boxes along the left side of the "Customization Options" section will expand the options for output format, reprojection, spatial subsetting, and resampling (**Figure 2-2**).

Including both Landsat and MODIS scenes in an order will result in equivalent customization options. "Customize Input Products" must be checked for product customization to be applied to MODIS scenes. For example, if ENVI is selected as an output format, both products will be produced as ENVI binaries. Another example, if the pixel resizing it set to 100 meters, both datasets will be sampled to 100 meters.

Figure 2-2 ESPA On Demand Customization Services

2.1.7.1   Output Format

Customized Input Products, Climate Data Records, and/or Spectral Indices can be output in three unique formats: GeoTIFF (".tif"), ENVI binary (".img"), NetCDF (".nc") or Hierarchical Data Format – Earth Observing System version 2 (HDF-EOS2; ".hdf"). The ESPA default file format is GeoTIFF. **Please be aware that not all off-the-shelf software is compatible with all data formats.**

2.1.7.2 Reproject Products

Any available products can be reprojected from the native Universal Transverse Mercator (UTM) or Polar Stereographic (Landsat Level-1 defaults), or from Sinusoidal (MODIS default) to a different UTM zone, Geographic, Albers Equal Area, Polar Stereographic, or Sinusoidal. The underlying software performing the reprojections is the Geospatial Data Abstraction Library (GDAL; http://www.gdal.org/.)

The Albers Equal Area selection requires user definition of projection parameters, and offers choices for datum. Sinusoidal and Polar Stereographic reprojections likewise allow entry of parameters. UTM accepts only a zone parameter and North/South hemisphere specification. Geographic projects coordinates into decimal degrees. A full list of parameters is provided in **Table 2-2**. A graphical example of reprojection is shown in **Figure 2-3**.

Table 2-2 Possible input parameters for product reprojection in ESPA

UTM Universal Transverse Mercator, WGS84 World Geodetic System 1984, NAD27 North American Datum 1927, NAD83 North American Datum 1983

		Projection				
		Albers Equal Area	**UTM**	**Geographic**	**Sinusoidal**	**Polar Stereographic**
	Units	Meters	Meters	Decimal Degrees	Meters	Meters
Input Parameters	**Latitude of Origin**	-90.0 to 90.0				
	Latitude True Scale					-180.0 to 180.0
	Longitudinal Pole					-90.0 to -60.0 (South), 60.0 to 90.0 (North)
	Central Meridian	-180.0 to 180.0			-180.0 to 180.0	
	1st Standard Parallel	-90.0 to 90.0				
	2nd Standard Parallel	-90.0 to 90.0				
	False Easting	Any float			Any float	Any float
	False Northing	Any float			Any float	Any float
	Datum	WGS84, NAD27, NAD83				
	Zone		1-60 North, 1-60 South			

Figure 2-3 Examples of ESPA On Demand Projection Parameter Entry

2.1.7.3   Modify Image Extents

If the user requires modification of image extents, the output projection must be specified, and entries for the corner points must be in the proper units (decimal degrees for Geographic; meters for Albers Equal Area, Polar Stereographic, Sinusoidal, and UTM).
Due to processing system limitations, image extents cannot be greater than 200 million pixels.

2.1.7.4   Pixel Resizing and Resampling

The last two customization options are for pixel resizing and resampling. Users can up- or down-sample the available products between 30 and 1,000-meters (m). Pixel size must be in decimal degrees if a Geographic projection is used.

Resampling methods include nearest neighbor, bilinear interpolation, and cubic convolution. As Quality Assurance (QA) bands use discrete, integer-level data, these bands are always resampled with nearest neighbor.

2.1.8   Intercomparison & Statistics

Statistics can be generated between geographically intersecting Landsat TM, ETM+, OLI/TIRS, and select MODIS datasets through ESPA by selecting "Plot Output Product Statistics" from the "Intercomparison & Statistics" heading. The statistics include plots, text files and CSV files of minimum, maximum, mean, and standard deviation of the image extents. A list of overlapping scene IDs can be generated from the Land Product Characterization System (LPCS) Explorer, which uses the same credentials as EarthExplorer and ESPA. Further information pertaining to statistics generation and output files are in the LPCS Product Guide.

2.1.9 Order Description

Users may enter an order description if they wish, to help identify the contents of the order for themselves. The "Submit" button at the bottom of the page will send the request to production.

As soon as the order is received, an email acknowledgment is delivered to the user. The email contains a link to tracking information for the order.

2.2   Order Tracking

Product requests are delivered to a hypertext transfer protocol (HTTP) site. Email notification of location is sent to the user when all files in the order have completed processing. Users can also use the "Show Orders" feature in the ESPA On Demand Interface to monitor the status of production and go directly to the download site as files complete.

Clicking on "Show Orders" will present an entry field requesting the email address associated with the order. The email address will be the same as what is on file in the user's EarthExplorer account. After entering the address and clicking "Submit," a listing is shown of all orders for that address (**Figure 2-4**).

The orders are assigned names, such that the email address, date of submission, and a unique identifier can be used to differentiate requests. For example: "scientist@usgs.gov-12172014-155922" is an order placed by scientist@usgs.gov on December 17, 2014.

The general status of each order is noted next to the order name, and whatever comments the user entered regarding the order are also displayed. Statistics are provided for each order, indicating the total number of products ordered, and the number of orders currently available for download.

Figure 2-4 ESPA On Demand "Show Orders" Page

The order names listed are linked to the distribution site. File-based details can be found there, and users can download any of the files in the order that have reached a complete state. An email notice is sent to the user only when all files are complete.

Figure 2-5 ESPA On Demand Distribution Page

2.2.1 Status Message

Each product within an order contains a status, indicating its activity within ESPA. Below is a table describing each status message and its meaning:

Status	Interpretation
Submitted	ESPA has received the order request, but has not yet determined source product availability.
On Cache	ESPA has found the source product(s) are available for processing.
On Order	The source product(s) are not immediately available, so ESPA has placed an order to the source and is awaiting the source product(s).
Queued	ESPA will attempt to process your orders once they reach the front of the queue.
Processing	ESPA is now processing your order.
Error	ESPA has received an order that could not be processed as requested. Errors will always be described in detail in the "Note" column of the order status. Some possible errors: • Solar zenith angle is too high (>76 degrees) to accurately retrieve surface reflectance • Auxiliary data are not yet available for the date requested
Retry	An order that could not previously be completed is set to be run again. For products missing auxiliary data for SR retrieval, ESPA retries every 24 hours.
Complete	The order has completed successfully, and is ready for download.
Unavailable	ESPA determined the order could not be completed successfully, so it will not be retried.

2.3   Download

As files complete processing, they can be downloaded along with their checksums any time directly from the site linked to the user's email address. Notification of delivery is not emailed back to the user until all the files in the order are complete. The download site contains compressed file packages (.tar.gz), inside of which will be the requested files. Additional information, such as the date ordered, date completed, and requested processing options are listed within the order download page (**Figure 2-5**).

Distribution is currently via direct download from an HTTP site, which generally requires each file be downloaded individually. Bulk downloads are possible however, utilizing the Really Simple Syndication (RSS) feed enabled for the ESPA pages. The RSS function can be used to script automated downloads, or alternatively, can be used in conjunction with the DownThemAll Firefox plugin (See details on following page).

Orders are available for download for 10 days. Any data not downloaded in this period will need to be reordered.

Download and Install DownThemAll Plug-in

Note: Ensure Firefox 7.X or greater is installed to successfully use DownThemAll

1. Open the Firefox Web browser

2. Access https://addons.mozilla.org/en-US/firefox/addon/downthemall/developers to download the DownThemAll FireFox plugin

3. Click on the "Add To Firefox+" button on the Web page to start the download of the DownThemAll plugin

4. When the "Software Installation" box appears, click on the 'Install' button to start the install of the DownThemAll plugin

5. Once DownThemAll plug-in has been installed, Firefox will want to restart the browser so the plug-in will take effect. Click on the "Restart Now" button when prompted.

6. Click the "Tools" menu on the browser toolbar and select "DownThemAll! Tools."

7. Select "Preferences," then click "Network" on the top menu (**Figure 2-6**).

8. In the "Location or domain" window at the bottom of the dialog box, type https://espa.cr.usgs.gov/ and click the "New Limit" button to the right.

9. The "Per-Server Limits" window will display as shown below. Set "Connections" to "Limited" and adjust the slider to "1." Click the "Create" button, then "OK" at the bottom of the dialog box.
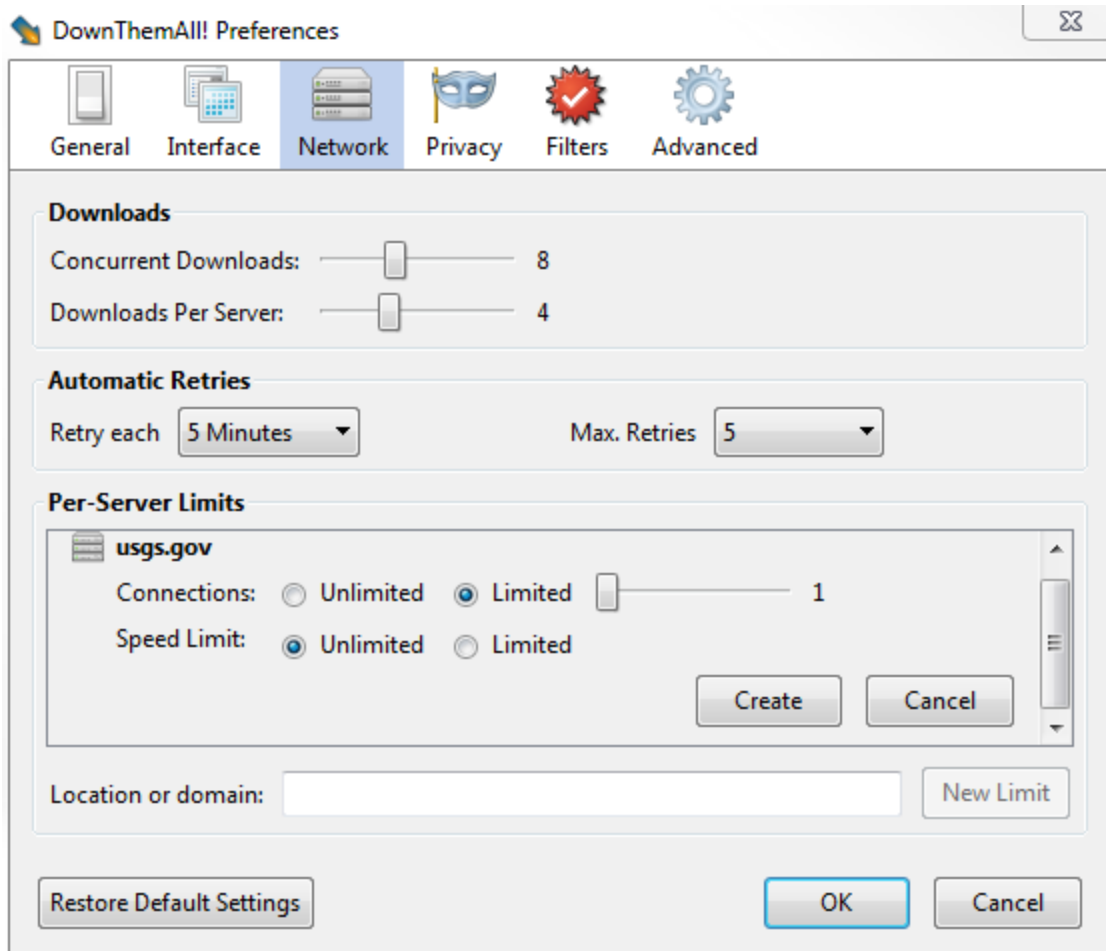
Figure 2-6 DownThemAll Network Preference Settings

Downloading All On-Demand Scenes with DownThemAll and RSS Feed

1) Open the Firefox Web browser

2) Go to https://espa.cr.usgs.gov/ordering/status and enter the email address associated with the ESPA on-demand orders

3) When the list of all on-demand orders comes back on the "Show Orders" page, click on the RSS feed icon by the label "Showing all orders for <your_e-mail_address>"

4) Once the list of all on-demand scenes is displayed, navigate to the browser Tools > DownThemAll! Tools > DownThemAll

5) At the DownThemAll Selection window, either:
   a. Select individual scenes to download by clicking the radio button next to each

individual scene or

b. Select all scenes by right-clicking and selecting "Select All", then right-clicking once more and selected "Check selected items"

6) After the scenes are selected, set the "Save Files in" directory to the local destination

7) To start the mass download of all the scenes, click on the "Start" button

2.3.1 ESPA Bulk Download Client

A Python-based Bulk Download client is available for downloading either a single ESPA order, or the entire order queue. At least Python 2.7 or greater is required to run the client.

The tool is available from https://github.com/USGS-EROS/espa-bulk-downloader. The user guide is available at https://landsat.usgs.gov/sites/default/files/documents/ESPA_Bulk_Downloader_User.pdf.

Section 3   **Application Programming Interface (API)**

3.1   Overview

The ESPA Application Programming Interface (API) is the underlying architecture on which the On Demand Interface operates. The API's basic functionality allows end-users to use a machine-to-machine interface to query order options, place orders, check order status and acquiring download URLs.

The API is implemented as a Representational State Transfer (REST) service using Hypertext Transfer Protocol (HTTP) and Java Script Object Notation (JSON) and therefore is compatible with most programming languages.

3.2   Documentation

The official ESPA API documentation is at https://github.com/USGS-EROS/espa-api.

Section 4 **User Services**

The Landsat CDRs, ECVs, and associated interfaces are supported by User Services staff at USGS EROS. Any questions, comments, or interface problems are welcomed through the Landsat "Contact Us" on-line correspondence form. Please indicate "Surface Reflectance Data" as the topic of regard. Electronic mail can also be sent to the customer service address included below, with the same indication of topic.

USGS User Services
https://landsat.usgs.gov/contact
custserv@usgs.gov

User support is available from 8:00 a.m. to 4:00 p.m. Central Time. Inquiries received outside of these hours will be addressed during the next business day.

Appendix A Landsat HDF File Characteristics

Table A-1 Landsat HDF File Characteristics

TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assurance, XML Extensible Markup Language, HDR Header file format, CFmask C version Function of Mask

NOTE: A Landsat 5 TM sceneID is used only as an example. Landsat 4 TM, Landsat 7 ETM+, and Landsat 8 OLI/TIRS files have similar characteristics.

NOTE: An ".img" file is included for each Science Data Set within an HDF file because each band is stored as an external SDS.

Description	Example File Size (bytes)	Example File Name	Science Data Sets
Source data file	16,239	LT50180341985263XXX04_level1.hdf	Grid • SDS1 band1 • SDS2 band2 • SDS3 band3 • SDS4 band4 • SDS5 band5 • SDS6 band61 • SDS7 band62 • SDS8 band7 Grid_15 • SDS1 band8
Source Binary file (9)	56,428,541	LT50180341985263XXX04_B*_hdf.img	NA
Source header file	497	LT50180341985263XXX04_level1.hdf.hdr	NA
Source Metadata	6,307	LT50180341985263XXX04_level1.xml	NA
TOA Reflectance data file	25,522	LT50180341985263XXX04_toa.hdf	• SDS1 toa_band1 • SDS2 toa_band2 • SDS3 toa_band3 • SDS4 toa_band4 • SDS5 toa_band5 • SDS6 toa_band7 • SDS7 toa_qa • SDS8 toa_band6 • SDS9 toa_band6_qa
TOA Reflectance Binary file (7)	112,857,082	LT50180341985263XXX04_toa_band*_hdf.img	NA
TOA Reflectance Quality Binary file	56,428,541	LT50180341985263XXX04_toa_qa_hdf.img	NA
TOA Band 6 Quality Binary file	56,428,541	LT50180341985263XXX04_toa_band6_qa_hdf.img	NA
TOA Reflectance header file	522	LT50180341985263XXX04_toa.hdf.hdr	NA

TOA Reflectance Metadata	8,993	LT50180341985263XXX04_toa.xml	NA
Surface Reflectance data file	33,812	LT50180341985263XXX04_sr.hdf	• SDS1 sr_band1 • SDS2 sr_band2 • SDS3 sr_band3 • SDS4 sr_band4 • SDS5 sr_band5 • SDS6 sr_band7 • SDS7 sr_atmos_opacity • SDS8 sr_fill_qa • SDS9 sr_ddv_qa • SDS10 sr_cloud_qa • SDS11 sr_cloud_shadow_qa • SDS12 sr_snow_qa • SDS13 sr_land_water_qa • SDS14 sr_adjacent_cloud_qa • SDS15 sr_cfmask
Surface Reflectance Binary file (6)	112,857,082	LT50180341985263XXX04_sr_band*_hdf.img	• NA
Surface Reflectance Quality Binary file (7)	56,428,541	LT50180341985263XXX04_sr_*_qa_hdf.img	• NA
Surface Reflectance Atmospheric Opacity Binary file	112,857,082	LT50180341985263XXX04_sr_atmos_opacity_hdf.img	• NA
Surface Reflectance CFmask Binary file	56,428,541	LT50180341985263XXX04_cfmask.hdf.img	• NA
Surface Reflectance header file	612	LT50180341985263XXX04_sr.hdf.hdr	• NA
Surface Reflectance Metadata	13,365	LT50180341985263XXX04_sr.xml	• NA

Appendix B MODIS HDF File Characteristics

Table B-1 MODIS HDF File Characteristics

MODIS Moderate Resolution Imaging Spectroradiometer, HDF Hierarchical Data Format, SDS Science Data Set, NDVI Normalized Difference Vegetation Index, EVI Enhanced Vegetation Index, VI Vegetation Index, NIR Near Infrared, MIR Middle Infrared, m meter, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, QA Quality Assurance, XML Extensible Markup Language, HDR Header file format

NOTE: A MODIS MYD13 sceneID is used only as an example. MOD13 and MOD/MYD09 files have similar characteristics, though include different output files for each product type.

NOTE: An ".img" file is included for each Science Data Set within an HDF file because each band is stored as an external SDS.

Description	Example File Size (bytes)	Example File Name	Science Data Sets
Source data file	28,348	*.hdf	Grid • SDS1 250m 16 days NDVI • SDS2 250m 16 days EVI • SDS3 250m 16 days VI Quality • SDS4 250m 16 days red reflectance • SDS5 250m 16 days NIR reflectance • SDS6 250m 16 days blue reflectance • SDS7 250m 16 days MIR reflectance • SDS8 250m 16 days view zenith angle • SDS9 250m 16 days sun zenith angle • SDS10 250m 16 days relative azimuth angle • SDS11 250m 16 days composite day of the year • SDS12 250m 16 days pixel reliability
Source Binary file (12)	61,956,549	*hdf.img	NA
Source header file	1,138	*.hdf.hdr	NA
Source Metadata	6,307	*.xml	NA

Appendix C Landsat Binary File Characteristics

Table C-1 Landsat Binary File Characteristics

TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assurance, XML Extensible Markup Language, HDR Header file format, BT Brightness Temperature, CFmask C version Function of Mask

NOTE: A Landsat 4 TM sceneID is used only as an example. Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI/TIRS files have similar characteristics.

Description	Example File Size (bytes)	Example File Name
Source Band data file (9)	59,638,671	LT40230281982346XXX04_B*.img
Source Band header file (9)	348	LT40230281982346XXX04_B*.hdr
TOA Reflectance data file (7)	119,277,342	LT40230281982346XXX04_toa_band*.img
TOA Reflectance header file (7)	348	LT40230281982346XXX04_toa_band*.hdr
TOA Reflectance Quality file (1)	59,638,671	LT40230281982346XXX04_toa_qa.img
TOA Reflectance Quality header file (1)	333	LT40230281982346XXX04_toa_qa.hdr
TOA Brightness Temperature Quality file (1)	59,638,671	LT40230281982346XXX04_toa_band6_qa.img
TOA Brightness Temperature Quality header file (1)	333	LT40230281982346XXX04_toa_bt_qa.hdr
Surface Reflectance data file (6)	119,277,342	LT40230281982346XXX04_sr_band*.img
Surface Reflectance header file (6)	352	LT40230281982346XXX04_sr_band*.hdr
Surface Reflectance Quality file (7)	59,638,671	LT40230281982346XXX04_sr_ *_qa.img
Surface Reflectance Quality header file (7)	332	LT40230281982346XXX04_sr_ *_qa.hdr
Surface Reflectance Atmospheric Opacity file (1)	119,277,342	LT40230281982346XXX04_sr_atmos_opacity.img
Surface Reflectance Atmospheric Opacity header file (1)	339	LT40230281982346XXX04_sr_atmos_opacity.hdr
Surface Reflectance CFmask file (1)	59,638,671	LT40230281982346XXX04_cfmask.img
Surface Reflectance CFmask header file (1)	336	LT40230281982346XXX04_cfmask.hdr
Metadata	32,139	LT40230281982346XXX04.xml

Appendix D MODIS Binary File Characteristics

Table D-1 MODIS Binary File Characteristics

MODIS Moderate Resolution Imaging Spectroradiometer, MOD09 MODIS Terra Surface Reflectance Product, MOD/MYD13 MODIS Terra/Aqua Vegetation Index Product, IMG ENVI Binary Image Format, NA Not Applicable, XML Extensible Markup Language, HDR Header file format

NOTE: A MOD09 sceneID is used only as an example. MYD09 and MOD/MYD13 files have similar characteristics, though include different output files for each product type.

Description	Example File Size (bytes)	Example File Name
Source Band data file (20)	234,626,529	MOD09GA.A2001024.h20v17.005.2006351175917.*.img
Source Band header file (20)	14,656	MOD09GA.A2001024.h20v17.005.2006351175917.*.hdr
Metadata	18,147	MOD09GA.A2001024.h20v17.005.2006351175917.xml

Appendix E MODIS GeoTIFF File Characteristics

Table E-1 MODIS GeoTIFF File Characteristics

MODIS Moderate Resolution Imaging Spectroradiometer, MOD09 MODIS Terra Surface Reflectance Product, MOD/MYD13 MODIS Terra/Aqua Vegetation Index Product, tif GeoTIFF File Format, km kilometer, m meter, QC Quality Control, num number, refl reflectance, sur surface, obscov observation coverage algorithm, iobs observation number, gflags geolocation flags, IMG ENVI Binary Image Format, NA Not Applicable, XML Extensible Markup Language, HDR Header file format

NOTE: A MOD09 sceneID is used only as an example. MYD09 and MOD/MYD13 files have similar characteristics, though include different output files for each product type.

Description	Example File Size (bytes)	Example File Name
Geolocation Flags (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_gflags_1.tif.tif
Observation Number in Coarser Grid (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_iobs_res_1.tif
Number of Observations (1km) (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_num_observations_1km.tif
Number of Observations (500m) (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_num_observations_500m.tif
Observation Coverage (500m) (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_obscov_500m_1.tif
Orbit Pointer (1)	163,838	MOD09GA.A2001024.h20v17.005.2006351175917_orbit_pnt_1.tif
Reflectance Band Quality (500m) (1)	653,623	MOD09GA.A2001024.h20v17.005.2006351175917_QC_500m_1.tif
Range (Pixel to Sensor) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_Range_1.tif
Sensor Azimuth (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_SensorAzimuth_1.tif
Sensor Zenith (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_SensorZenith_1.tif
Solar Azimuth (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_SolarAzimuth_1.tif
Solar Zenith (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_SolarZenith_1.tif
Reflectance Data State QA (1km) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_state_1km_1.tif
Surface Reflectance Band 1 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b01_1.tif
Surface Reflectance Band 2 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b02_1.tif
Surface Reflectance Band 3 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b03_1.tif
Surface Reflectance Band 4 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b04_1.tif
Surface Reflectance Band 5 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b05_1.tif

Surface Reflectance Band 6 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b06_1.tif
Surface Reflectance Band 7 (500m) (1)	327,059	MOD09GA.A2001024.h20v17.005.2006351175917_sur_refl_b07_1.tif
Metadata	18,059	MOD09GA.A2001024.h20v17.005.2006351175917.xml

Appendix F Acronyms

Acronym	Description
09A1	MODIS Surface Reflectance 8-Day L3 Global 500m
09GA	MODIS Surface Reflectance Daily L2G Global 1 km and 500m
09GQ	MODIS Surface Reflectance Daily L2G Global 250m
09Q1	MODIS Surface Reflectance 8-Day L3 Global 250m
13Q1	MODIS Vegetation Indices 16-Day L3 Global 250m
13A1	MODIS Vegetation Indices 16-Day L3 Global 500m
13A2	MODIS Vegetation Indices 16-Day L3 Global 1km
13A3	MODIS Vegetation Indices Monthly L3 Global 1km
API	Application Programming Interface
BT	Brightness Temperature
CDR	Climate Data Record
CFmask	C version of Fmask
CSV	Comma Separated Values
DOI	Department of the Interior
ECV	Essential Climate Variable
ENVI	Exelis Visual Information Solutions
EROS	Earth Resources Observation and Science
ESPA	EROS Science Processing Architecture
ETM+	Enhanced Thematic Mapper Plus
EVI	Enhanced Vegetation Index
Fmask	Function of Mask
GDAL	Geospatial Data Abstraction Library
GeoTIFF	Georeferenced Tagged Image File Format
GloVis	USGS Global Visualization Viewer
GLS	Global Land Survey
HDF-EOS2	Hierarchical Data Format for Earth Observation Systems (version 2)
HDR	Header File
HTTP	Hypertext Transfer Protocol
JSON	Java Script Object Notation
km	Kilometer
LaSRC	Landsat Surface Reflectance Code
LPCS	Land Product Characterization System
LP DAAC	Land Processes Distributed Active Archive Center
m	Meter
MOD09	MODIS Surface Reflectance – Terra Platform
MYD09	MODIS Surface Reflectance – Aqua Platform
MOD13	MODIS Vegetation Indices – Terra Platform
MYD13	MODIS Vegetation Indices – Aqua Platform

MODIS	Moderate Resolution Imaging Spectroradiometer
NAD27	North American Datum 1927
NAD83	North American Datum 1983
NBR	Normalized Burn Ratio
NBR2	Normalized Burn Ratio 2
NDMI	Normalized Difference Moisture Index
NDVI	Normalized Difference Vegetation Index
NC	NetCDF File Format
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration
ODI	On Demand Interface
OLI	Operational Land Imager
REST	Representational State Transfer
RSS	Really Simple Syndication
SAVI	Soil Adjusted Vegetation Index
sceneID	Landsat Scene Identifier
SDS	Science Data Set
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
TOA	Top of Atmosphere
URL	Uniform Resource Locator
USGS	U.S. Geological Survey
WGS84	World Geodetic System 1984
XML	Extensible Markup Language